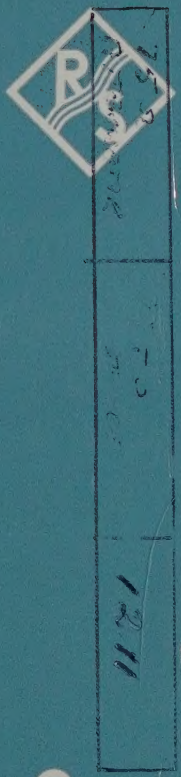
180 42

105/CA 877



ROHDE & SCHWARZ

BESCHREIBUNG

Instruction Book

UNBALANCED VHF STANDARD ATTENUATOR

Type DPR

DC to 300 mc

0 to 100 db

Z_0 = 50 ohms	BN 18042/50
Z_0 = 60 ohms	BN 18042/60
Z_0 = 75 ohms	BN 18042/75

Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNr.)of the set when asking for technical information and, in particular, when ordering repair parts.

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1. Specifications

Frequency range . . .	d-c to 300 mc
Attenuation range . .	0 to 100 db
Vernier steps	10 x 1 db
Coarse steps	6 x 10 db 1 x 30 db
Accuracy Vernier steps	±0.01 db per step from d-c to 30 mc ±0.02 db per step from 30 to 100 mc ±0.2 db total from 100 to 300 mc
Coarse steps	±0.1 db per step from d-c to 300 mc
Characteristic impedance, either end . .	50 Ω (BN 18042/50) 60 Ω (BN 18042/60) 75 Ω (BN 18042/75)
Accuracy of the characteristic impedance	VSWR is 1.15
Relative time delay .	$0.5 \cdot 10^{-9}$ sec, approx.
Maximum input power .	0.4 w
Maximum input voltage	5 v for sine wave 300 v for pulses

Connectors	2 R&S short-stroke connectors Dezifix B
Dimensions	500 x 195 x 260 mm (R&S Standard Cabinet 45)
Weight	11 kg

2. Uses

The VHF Standard Attenuator Type DPR BN 18042 finds manifold application in the development, manufacture and monitoring of audio- and radio-frequency communication equipments. It enables accurately-known fractional voltages to be set and is also a precise standard for attenuation measurements in the entire frequency range from the lowest audio frequencies to the upper limit of the VHF range, 300 mc. A few examples of applications are given below and suggestions are made on how to provide cable connections which at the highest frequencies permit full benefit to be drawn from the excellent qualities of this attenuation box.

2.1 The Standard Attenuator Used as a Voltage Divider

Fig.1 shows the arrangement set up to divide a known input voltage E_1 down to a very small and accurately-known output voltage E_2 needed, for example, in sensitivity measurements on receivers. For a desired voltage ratio E_1/E_2,

the attenuation box should be adjusted for the attenuation (db)

$$\alpha = 20 \log_{10} \frac{E_1}{E_2}$$

The required attenuation α can also be determined, to a good approximation, from the nomogram in Fig.2. It is imperative that the attenuator be match-terminated. The standard attenuator and receiver can readily be connected

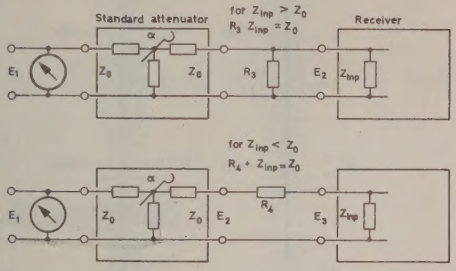


Fig.1. Standard attenuator terminated without mismatch, with input impedance Z_{inp} of the receiver differing from Z_0

to each other provided the input impedance Z_{inp} of the receiver is equal to the characteristic impedance Z_0 of the standard attenuator. Otherwise, the correct termination should be achieved by means of a shunt or series resistor as shown in Fig.1. With $Z_{inp} > Z_0$, a condition often encountered in practice, a resistor

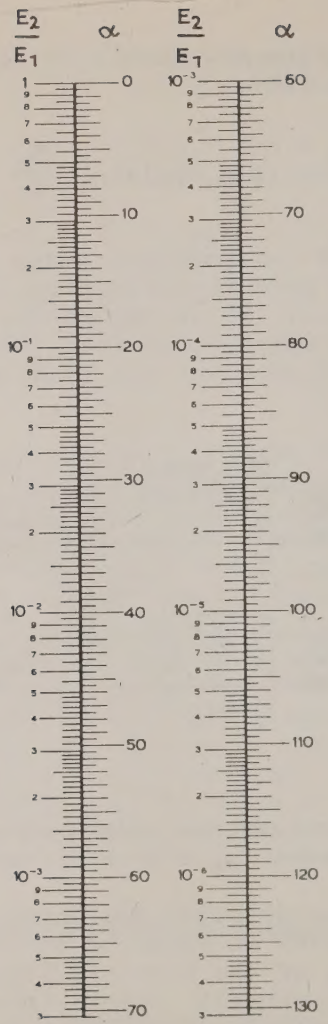


Fig.2. Nomogram showing the attenuation α (in db) for a desired voltage ratio E_2/E_1

$$R_3 = \frac{Z_{inp} \cdot Z_0}{Z_{inp} - Z_0}$$

should be connected across the receiver, whereas with $Z_{inp} < Z_0$ a series resistor

$$R_4 = Z_{inp} - Z_0$$

must be inserted. In this case, the voltage division

$$\frac{E_2}{E_3} = \frac{Z_{inp} + R_4}{Z_{inp}}$$

effected by Z_{inp} and R_4 should be taken into account.

2.2 Gain Measurement

Gain measurements can be made as shown in Fig.3. Here also the standard attenuator must be match-terminated. Often this requirement is satisfied by the input impedance Z_{inp} of the amplifier. However, if Z_{inp} is high as compared to the characteristic impedance Z_0 of the standard attenuator, the termination must be made by a suitable shunt resistor. The attenuation should be adjusted until the output voltage E_2 of the amplifier is equal to the input voltage E_1 of the attenuation box. Then the gain A is equal to the attenuation α adjusted for, that is to say,

if $E_2 = E_1$, then $A = \alpha$.

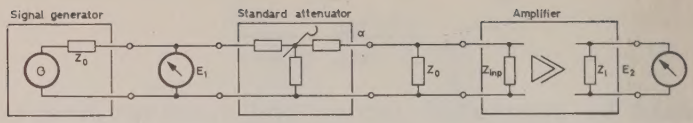


Fig.3 Gain measurement with a standard attenuator and two voltmeters

Fig.4 shows a method of gain measurement by voltage comparison. An uncalibrated voltage indicator of high input impedance Z_{inp} will do. Again the standard attenuator should be terminated in an impedance having the value of the characteristic impedance Z_0. This requirement is fulfilled if the input impedance Z_{inp} of the amplifier equals Z_0. However, with $Z_{inp} > Z_0$ or $Z_{inp} < Z_0$ the correct termination should be obtained by a shunt or series resistor as indicated in section 2.1 (Fig.1). Where $Z_{inp} < Z_0$, one has to allow for the voltage drop effected by R_4 and Z_{inp}. If necessary, also the output of the amplifier should be loaded with an impedance $Z_1 = Z_{out}$.

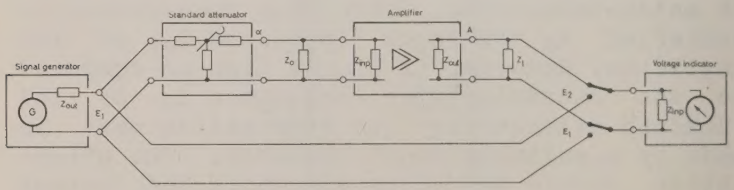


Fig.4. Gain measurement with a standard attenuator and one voltage indicator

The measurement is made as follows: First connect the voltmeter to the signal generator and

adjust the signal generator for a voltage E_1 which is roughly equal to the normal output voltage E_2 of the amplifier. However, the permissible input of 5 v to the attenuation box should not be exceeded. Without changing the magnitude of E_1, connect the voltmeter to the output of the amplifier and vary the attenuation on the standard attenuator until the amplifier output voltage is equal to the signal generator voltage. Then the gain A is equal to the attenuator setting; that is to say,

$$\text{if } E_2 = E_1, \text{ then } A = \alpha.$$

2.3 Attenuation Measurement

The attenuation can readily be measured with the standard attenuator used for voltage comparison. The test rig is shown in Fig.5. Here also it is unnecessary to calibrate the volt-

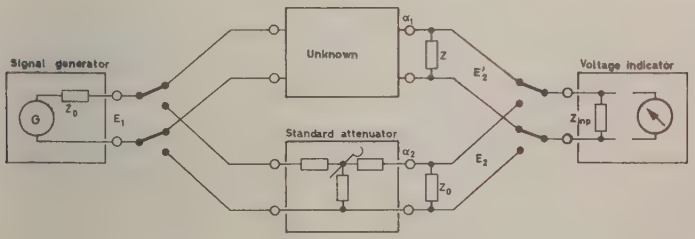


Fig.5. Attenuation measurement with the standard attenuator

are indicator as it serves only for indication and not for measuring. For voltage indication, preferably use should be made of a unit having a very high input impedance Z_{inp} in relation to

Z_0; the item under test and the standard attenuator should be terminated in Z_0. With the signal generator output E_1 kept on a constant value, the standard attenuator should subsequently be varied until its output voltage E_2 is equal to the output voltage E'_2 of the item under test. The attenuations are then identical and the attenuation α_1 of the item under test can be read directly from the attenuation box, that is to say,

$$\text{if } E'_2 = E_2, \text{ then } \alpha_1 = \alpha_2.$$

In this way the frequency-dependent attenuation of an item can be measured at various frequencies in a relatively short time.

Its phase angle being very small up to the cut-off frequency, the standard attenuator permits, in addition to attenuation measurements, the determination of the phase shift occurring in the item under test as a function of frequency.

2.4 Impedance Transformation

In practical measurements, often a given standard attenuator with its characteristic impedance Z_{01} must be inserted, with correct impedance match, into a line whose characteristic impedance Z_{02} differs from Z_{01}. The impedance transformation Z_{01}/Z_{02} can be achieved by connecting an unbalanced four-terminal network ahead of and after the standard attenuator. In the simplest case, this network may be made up of two resistors R_1 and R_2. The circuit arrangement for the condition $Z_{02} < Z_{01}$ is shown

in Fig.6. However, this method of impedance transformation has the effect that each of these four-terminal networks forms an additional stage of attenuation. Hence there still remains $\alpha_{inp} + \alpha_{out}$ if the attenuation of the standard attenuator is brought to zero.

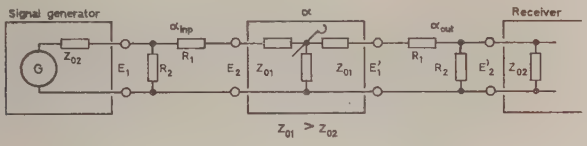


Fig.6. Standard attenuator inserted without mismatch into a line of lower characteristic impedance

For the calculation of the four-terminal networks according to Fig.6 holds

$$R_1 = \sqrt{Z_{01}\ (Z_{01} - Z_{02})} \qquad R_2 = Z_{02}\ \sqrt{\frac{Z_{01}}{Z_{01} - Z_{02}}}$$

The voltage division due to the four-terminal network at the input is

$$\frac{E_1}{E_2} = \frac{R_1}{Z_{01}} + 1 = \sqrt{\frac{Z_{01} - Z_{02}}{Z_{01}}} + 1$$

and the attenuation

$$\alpha_{inp} = 20 \log_{10} \frac{E_1}{E_2}$$

The four-terminal network at the output produces the voltage division

$$\frac{E'_1}{E'_2} = \frac{R_1(R_2 + Z_{02})}{R_2 \cdot Z_{02}} + 1 = \frac{\sqrt{Z_{01}(Z_{01} - Z_{02})} + Z_{01}}{Z_{02}}$$

and the attenuation

$$\alpha_{out} = 20 \log_{10} \frac{E'_1}{E'_2} .$$

The total attenuation between the signal generator and receiver is then

$$\alpha_{total} = \alpha_{inp} + \alpha + \alpha_{out}$$

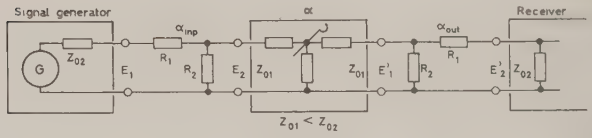


Fig.7. Standard attenuator inserted without mismatch into a line of higher characteristic impedance

The circuit arrangement for the condition $Z_{02} > Z_{01}$ is shown in Fig.7. For the calculation of the four-terminal networks holds

$$R_1 = \sqrt{Z_{02}(Z_{02} - Z_{01})} \qquad R_2 = Z_{01}\sqrt{\frac{Z_{02}}{Z_{02} - Z_{01}}}$$

$$\frac{E_1}{E_2} = \frac{R_1(R_2 + Z_{01})}{R_2 \cdot Z_{01}} + 1 = \frac{\sqrt{Z_{02}(Z_{02} - Z_{01})} + Z_{02}}{Z_{01}}$$

$$\alpha_{inp} = 20 \log_{10} \frac{E_1}{E_2}$$

$$\frac{E'_1}{E'_2} = \frac{R_1}{Z_{02}} + 1 = \sqrt{\frac{Z_{02} - Z_{01}}{Z_{02}}} + 1$$

$$\alpha_{out} = 20 \log_{10} \frac{E'_1}{E'_2}$$

This manner of impedance transformation will, of course, be chosen only provided there are no suitable transformers available for the frequency range in question or provided the

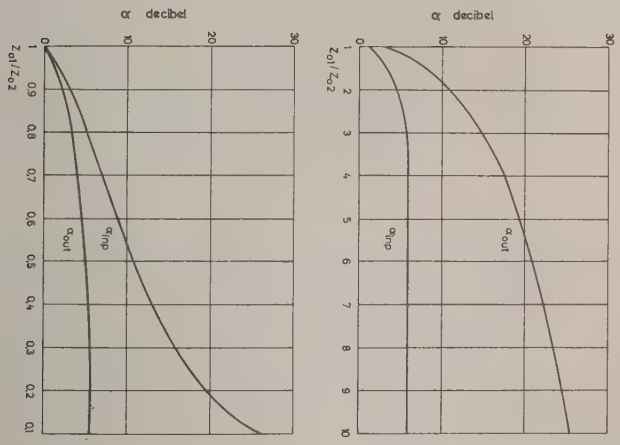


Fig.8. Additional attenuation as a function of the impedance transformation Z_{01}/Z_{02}

additional attenuation $\alpha_{inp} + \alpha_{out}$ can be tolerated for the respective measuring purpose. The curves in Fig.8 reveal the additional attenuation to be expected with a given impedance transformation Z_{01}/Z_{02}.

The most frequently required impedance transformations can be made when using the R&S UHF Attenuators Type DPF:

BN	Z_{01}	<⟶>	Z_{02}	attenuation
18033	75 Ω	<⟶>	60 Ω	10 db
18034	75 Ω	<⟶>	50 Ω	12 db
18035	60 Ω	<⟶>	50 Ω	10 db

The specified attenuation refers to 2 attenuators. These attenuators are suitable for the frequency range d-c to 1000 mc.

2.5 Connecting Cables and Disturbance Voltage

Whether fractional voltages can be obtained depends largely on the electric properties of the connecting cables that connect the attenuation box between the signal generator and receiver. Furthermore it depends upon the location of the earthing point of the test setup. If it is necessary at all to earth the test setup, it is advantageous to earth the signal generator only. The properties of the cables and plug connections play an important role at radio frequencies. If the mutual impedances of the cables or connectors are too high, it may be, as shown in Fig.9, that the r-f voltage

across the receiver input is higher than corresponds to the attenuator setting. This r-f disturbance voltage termed E_k is caused as follows:

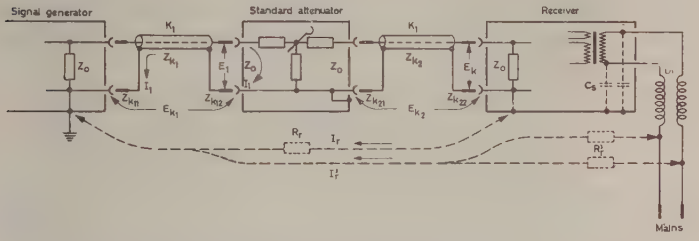


Fig. 9. Representation of disturbing influences occurring when a standard attenuator is inserted in a test setup

The current $I_1 = E_1/Z_0$ entering the input of the attenuation box flows through the mutual impedances $Z_{k12} - Z_{k1} - Z_{k11}$ (plug-cable-plug) and causes the voltage drop

$$E_{k1} = I_1 \ (Z_{k11} + Z_{k1} + Z_{k12}).$$

In the outer conductor of the coaxial cable K_2, this voltage in turn results in a current

$$I_r = \frac{E_{k1}}{Z_{k21} + Z_{k2} + Z_{k22} + R_r}$$

which flows through the mutual impedances $Z_{k21} - Z_{k2} - Z_{k22}$ and back to the signal generator through the return-path resistance R_r. This return-path resistance R_r is, particularly at higher frequencies, due only to the stray capacitance existing between the receiver and signal generator (10 to 50 µµf) and is generally much higher than the sum of the mutual impedances $Z_{k21} + Z_{k2} + Z_{k22}$. Consequently, the

current I_r too is virtually determined only by the magnitude of R_r. The disturbance voltage E_k appearing across the receiver input is then equal to the current I_r multiplied by the total mutual impedance of the connection between the standard attenuator and receiver; that is to say,

$$E_k \approx I_r \ (Z_{k21} + Z_{k2} + Z_{k22})$$

The value of E_k may also be obtained to a good approximation from

$$E_k = I_1 \frac{(Z_{k11} + Z_{k1} + Z_{k12}) \ (Z_{k21} + Z_{k2} + Z_{k22})}{R_r}$$

or

$$E_k = E_1 \frac{(Z_{k11} + Z_{k1} + Z_{k12}) \ (Z_{k21} + Z_{k2} + Z_{k22})}{Z_0 \quad R_r}$$

Here Z_{k1}, Z_{k2} are the mutual impedances of the cables and Z_{k11} to Z_{k22} the mutual impedances of the connectors while E_1 is the input voltage of the standard attenuator and Z_0 the characteristic impedance of the standard attenuator.

Where the signal generator and receiver are connected to the same a-c power supply, as is mostly the case, it is also possible that a return-path resistance R'_r is formed through the wiring capacitance C_w in the power section of the sets and through their power cables. This return-path resistance results in an additional return-path current I'_r which might

be much greater than the current I_r flowing via the stray capacitance. However, if two chokes are connected into the power lead of the receiver, I'_r becomes correspondingly small provided these chokes offer a high impedance to the test frequency. To minimize the disturbance voltage E_k it is hence necessary to use very short connecting cables ($< 1\,1/2$ ft.), to ensure good contact of the plug connections and maximum return-path resistance. The above explanation shows that, with a given mutual impedance, the smallest possible input voltage E_1 should be adjusted in order to obtain a very small output voltage, since the disturbance voltage E_k is then likewise correspondingly smaller.

3. Circuitry and Construction

The circuit diagram of the attenuation box is shown in Fig.10. It consists of a 30-db stage, a 6 x 10-db stage and a 10 x 1-db stage. The first stage consists of three π sections of 10 db each. In the second stage, 6 x 10 db, provision has been made to insert the π sections by means of a special switch which series-connects more or fewer sections into a chain giving the desired attenuation and interrupts this chain at the respective attenuation step. Thus the unused portion of the chain remains disconnected. This arrangement has the advantage over earlier models that, e. g. for obtaining an attenuation of 60 db, it is not a single high series impedance that must be inserted, but a chain of 6 sections

having each a low series impedance. Thus unavoidable wiring capacitances have little influence on the attenuation so that the cutoff frequency is correspondingly high. A similar method has been chosen in the third stage of 10 x 1 db. Here each step has its own π section of suitable design. The switch having two wiper arms will always single out one section while the others remain disconnected.

A direct connection between the inner screening and the steel cabinet of the attenuation box exists only at the input connector. Thus undesirable coupling currents are minimized. At the upper frequency limit, the characteristic impedance is no longer exactly 50 Ω, 60 Ω, or 75 Ω resistive. Dependent upon the attenuation setting, the deviations may be inductive, capacitive or resistive. However, they are small only and have negligible effect on the attenuation setting. The impedance at the input and output ends lies within the VSWR circle 1.15 about 50 Ω, 60 Ω, or 75 Ω resistive. The relative time delay of 0.5×10^{-9} sec is small enough to be of no importance even in television engineering. The maximum permissible input voltage is 5 v, corresponding to an admissible power input of 0.4 w. Pulse peak voltages up to 300 v may be applied to the input if the effective pulse power does not exceed 0.4 w. The attenuation box also attenuates very short pulses without distorting their form.

4. Operation

To connect the standard attenuator between a signal generator and a receiver, use a coaxial patch cord whose characteristic impedance is equal to that of the standard attenuator. This is the more important the higher the frequency and the greater the desired attenuation. In the audio-frequency field, the characteristic impedance of relatively short lengths of cables plays an unimportant role only, whereas in the VHF field (30 to 300 mc) mismatch might lead to a large voltage transformation. At these frequencies it is imperative that the entire assembly consisting of the standard attenuator + plug + cable + load have a uniform characteristic impedance.

Special consideration should be given to the mutual impedances of the patch cords if it is necessary to use high attenuation. Section 2.5 indicates in greater detail how to proceed in order to obtain an accurately-known fractional r-f voltage across a load (receiver). At medium frequencies and relatively small attenuation, coaxial cables provided with a double-braid jacket are usually adequate. However, very high frequencies and heavy attenuation dictate the use of solid-jacket cables as these have the lowest mutual impedance.

The operation of the attenuation box does not require any further explanation. The attenuation is easily set with the aid of the knobs and directly read in terms of decibel. Adding up of attenuation settings is unnecessary as this is automatically done by the set.

5. Maintenance

The standard attenuator does not require any particular maintenance. However, after a long period in service it may become necessary to clean the switch contacts of the special switches. To do this, first loosen the cheese-head screws at the left- and right-hand edges of the front panel, take the standard attenuator out of its box and remove the cover of the attenuator stages. Then the switching contacts are accessible and may be cleaned in the usual way.

6. Table of Replaceable Parts

(Reference numbers according to circuit diagram)

Ref. No.	Designation	Ratings	R&S Stock No. with Z_0 =
R1	Resistor, depos. carbon	71 Ω/0.25 w	WF 71/0,25 50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25 60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25 75 Ω
R2	Resistor, depos. carbon	71 Ω/0.25 w	WF 71/0,25 50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25 60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25 75 Ω
R3	Resistor, depos. carbon	71 Ω/0.25 w	WF 71/0,25 50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25 60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25 75 Ω
R4	Resistor, depos. carbon	96.2 Ω/0.5 w	WF 96,2/0,5 50 Ω
		115.5 Ω/0.5 w	WF 115,5/0,5 60 Ω
		144.5 Ω/0.5 w	WF 144,5/0,5 75 Ω
R5	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25 50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25 60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25 75 Ω
R6	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25 50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25 60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25 75 Ω
R7	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25 50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25 60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25 75 Ω
R8	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25 50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25 60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25 75 Ω
R9	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25 50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25 60 Ω
		144.5 Ω/0.25 w	WF 114,5/0,25 75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
R10	Resistor,depos.carbon	50 Ω/0.25 w	WF 50/0,25	50 Ω
		60 Ω/0.25 w	WF 60/0,25	60 Ω
		75 Ω/0.25 w	WF 75/0,25	75 Ω
R11	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R12	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R13	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R14	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R15	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R16	Resistor,depos.carbon	71 Ω/0.25 w	WF 71/0,25	50 Ω
		85.2 Ω/0.25 w	WF 85,2/0,25	60 Ω
		106.7 Ω/0.25 w	WF 106,7/0,25	75 Ω
R17	Resistor,depos.carbon	96.2 Ω/0.5 w	WF 96,2/0,5	50 Ω
		115.5 Ω/0.5 w	WF 115,5/0,5	60 Ω
		144.5 Ω/0.5 w	WF 144,5/0,25	75 Ω
R18	Resistor,depos.carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R19	Resistor,depos.carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 155,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
R20	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R21	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R22	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R23	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R24	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R25	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R26	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R27	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R28	Resistor, depos. carbon	96.2 Ω/0.25 w	WF 96,2/0,25	50 Ω
		115.5 Ω/0.25 w	WF 115,5/0,25	60 Ω
		144.5 Ω/0.25 w	WF 144,5/0,25	75 Ω
R29	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25	50 Ω
		60 Ω/0.25 w	WF 60/0,25	60 Ω
		75 Ω/0.25 w	WF 75/0,25	75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
R30	Resistor,depos.carbon	5.76 Ω/0.5 w	WF 5,76/0,5	50 Ω
		6.91 Ω/0.5 w	WF 6,91/0,5	60 Ω
		8.64 Ω/0.5 w	WF 8,64/0,5	75 Ω
R31	Resistor,depos.carbon	11.6 Ω/0.5 w	WF 11,6/0,5	50 Ω
		13.92 Ω/0.5 w	WF 13,92/0,5	60 Ω
		17.4 Ω/0.5 w	WF 17,4/0,5	75 Ω
R32	Resistor,depos.carbon	17.6 Ω/0.5 w	WF 17,6/0,5	50 Ω
		21.12 Ω/0.5 w	WF 21,12/0,5	60 Ω
		26.4 Ω/0.5 w	WF 26,4/0,5	75 Ω
R33	Resistor,depos.carbon	23.8 Ω/0.5 w	WF 23,8/0,5	50 Ω
		28.56 Ω/0.5 w	WF 28,56/0,5	60 Ω
		35.8 Ω/0.5 w	WF 35,8/0,5	75 Ω
R34	Resistor,depos.carbon	30.4 Ω/0.5 w	WF 30,4/0,5	50 Ω
		36.42 Ω/0.5 w	WF 36,42/0,5	60 Ω
		45.6 Ω/0.5 w	WF 45,6/0,5	75 Ω
R35	Resistor,depos.carbon	37.4 Ω/0.5 w	WF 37,4/0,5	50 Ω
		44.82 Ω/0.5 w	WF 44,82/0,5	60 Ω
		56.0 Ω/0.5 w	WF 56,0/0,5	75 Ω
R36	Resistor,depos.carbon	44.7 Ω/0.5 w	WF 44,7/0,5	50 Ω
		53.7 Ω/0.5 w	WF 53,7/0,5	60 Ω
		67.2 Ω/0.5 w	WF 67,2/0,5	75 Ω
R37	Resistor,depos.carbon	52.8 Ω/0.5 w	WF 52,8/0,5	50 Ω
		63.42 Ω/0.5 w	WF 63,42/0,5	60 Ω
		79.3 Ω/0.5 w	WF 79,3/0,5	75 Ω
R38	Resistor,depos.carbon	61.5 Ω/0.5 w	WF 61,5/0,5	50 Ω
		73.86 Ω/0.5 w	WF 73,86/0,5	60 Ω
		92.3 Ω/0.5 w	WF 92,3/0,5	75 Ω
R39	Resistor,depos.carbon	71 Ω/0.5 w	WF 71/0,5	50 Ω
		85.2 Ω/0.5 w	WF 85,2/0,5	60 Ω
		106.7 Ω/0.5 w	WF 106,7/0,5	75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
R40	Resistor, depos. carbon	871 Ω/0.5 w	WF 871/0,5	50 Ω
		1045 Ω/0.5 w	WF 1045/0,5	60 Ω
		1300 Ω/0.5 w	WF 1300/0,5	75 Ω
R41	Resistor, depos. carbon	871 Ω/0.5 w	WF 871/0,5	50 Ω
		1045 Ω/0.5 w	WF 1045/0,5	60 Ω
		1300 Ω/0.5 w	WF 1300/0,5	75 Ω
R42	Resistor, depos. carbon	436 Ω/0.5 w	WF 436/0,5	50 Ω
		524 Ω/0.5 w	WF 524/0,5	60 Ω
		651 Ω/0.5 w	WF 651/0,5	75 Ω
R43	Resistor, depos. carbon	436 Ω/0.5 w	WF 436/0,5	50 Ω
		524 Ω/0.5 w	WF 524/0,5	60 Ω
		651 Ω/0.5 w	WF 651/0,5	75 Ω
R44	Resistor, depos. carbon	292.5 Ω/0.5 w	WF 292,5/0,5	50 Ω
		351 Ω/0.5 w	WF 351/0,5	60 Ω
		438.8 Ω/0.5 w	WF 438,8/0,5	75 Ω
R45	Resistor, depos. carbon	292.5 Ω/0.5 w	WF 292,5/0,5	50 Ω
		351 Ω/0.5 w	WF 351/0,5	60 Ω
		438.8 Ω/0.5 w	WF 438,8/0,5	75 Ω
R46	Resistor, depos. carbon	221 Ω/0.5 w	WF 221/0,5	50 Ω
		265.5 Ω/0.5 w	WF 265,5/0,5	60 Ω
		231.4 Ω/0.5 w	WF 231,4/0,5	75 Ω
R47	Resistor, depos. carbon	221 Ω/0.5 w	WF 221/0,5	50 Ω
		265.5 Ω/0.5 w	WF 265,5/0,5	60 Ω
		231.4 Ω/0.5 w	WF 231,4/0,5	75 Ω
R48	Resistor, depos. carbon	178 Ω/0.5 w	WF 178/0,5	50 Ω
		214 Ω/0.5 w	WF 214/0,5	60 Ω
		267.8 Ω/0.5 w	WF 267,8/0,5	75 Ω
R49	Resistor, depos. carbon	178 Ω/0.5 w	WF 178/0,5	50 Ω
		214 Ω/0.5 w	WF 214/0,5	60 Ω
		267.8 Ω/0.5 w	WF 267,8/0,5	75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
R50	Resistor, depos.carbon	150.5 Ω/0.5 w	WF 150,5/0,5	50 Ω
		180.7 Ω/0.5 w	WF 180,7/0,5	60 Ω
		225.8 Ω/0.5 w	WF 225,8/0,5	75 Ω
R51	Resistor, depos.carbon	150.5 Ω/0.5 w	WF 150,5/0,5	50 Ω
		180.7 Ω/0.5 w	WF 180,7/0,5	60 Ω
		225.8 Ω/0.5 w	WF 225,8/0,5	75 Ω
R52	Resistor, depos.carbon	131 Ω/0.5 w	WF 131/0,5	50 Ω
		157 Ω/0.5 w	WF 157/0,5	60 Ω
		196.1 Ω/0.5 w	WF 196,1/0,5	75 Ω
R53	Resistor, depos.carbon	131 Ω/0.5 w	WF 131/0,5	50 Ω
		157 Ω/0.5 w	WF 157/0,5	60 Ω
		196.1 Ω/0.5 w	WF 196,1/0,5	75 Ω
R54	Resistor, depos.carbon	116.2 Ω/0.5 w	WF 116,2/0,5	50 Ω
		139.6 Ω/0.5 w	WF 139,6/0,5	60 Ω
		174.2 Ω/0.5 w	WF 174,2/0,5	75 Ω
R55	Resistor, depos.carbon	116.2 Ω/0.5 w	WF 116,2/0,5	50 Ω
		139.6 Ω/0.5 w	WF 139,6/0,5	60 Ω
		174.2 Ω/0.5 w	WF 174,2/0,5	75 Ω
R56	Resistor, depos.carbon	105 Ω/0.5 w	WF 105/0,5	50 Ω
		126 Ω/0.5 w	WF 126/0,5	60 Ω
		157.5 Ω/0.5 w	WF 157,5/0,5	75 Ω
R57	Resistor, depos.carbon	105 Ω/0.5 w	WF 105/0,5	50 Ω
		126 Ω/0.5 w	WF 126/0,5	60 Ω
		157.5 Ω/0.5 w	WF 157,5/0,5	75 Ω
R58	Resistor, depos.carbon	96.2 Ω/0.5 w	WF 96,2/0,5	50 Ω
		115.5 Ω/0.5 w	WF 115,5/0,5	60 Ω
		144.5 Ω/0.5 w	WF 144,5/0,5	75 Ω
R59	Resistor, depos.carbon	96.2 Ω/0.5 w	WF 96,2/0,5	50 Ω
		115.5 Ω/0.5 w	WF 115,5/0,5	60 Ω
		144.5 Ω/0.5 w	WF 144,5/0,5	75 Ω

Ref. No.	Designation	Ratings	R&S Stock No.	with Z_0 =
S1	Switch (attenuator)		E 237/30	
S2	Switch (attenuator)		E 237	
S3	Switch (attenuator)		E 237/3	

Apart from R10 and R29, all resistors have a tolerance of ±1 %. The carbon layer on the resistors is not coiled.

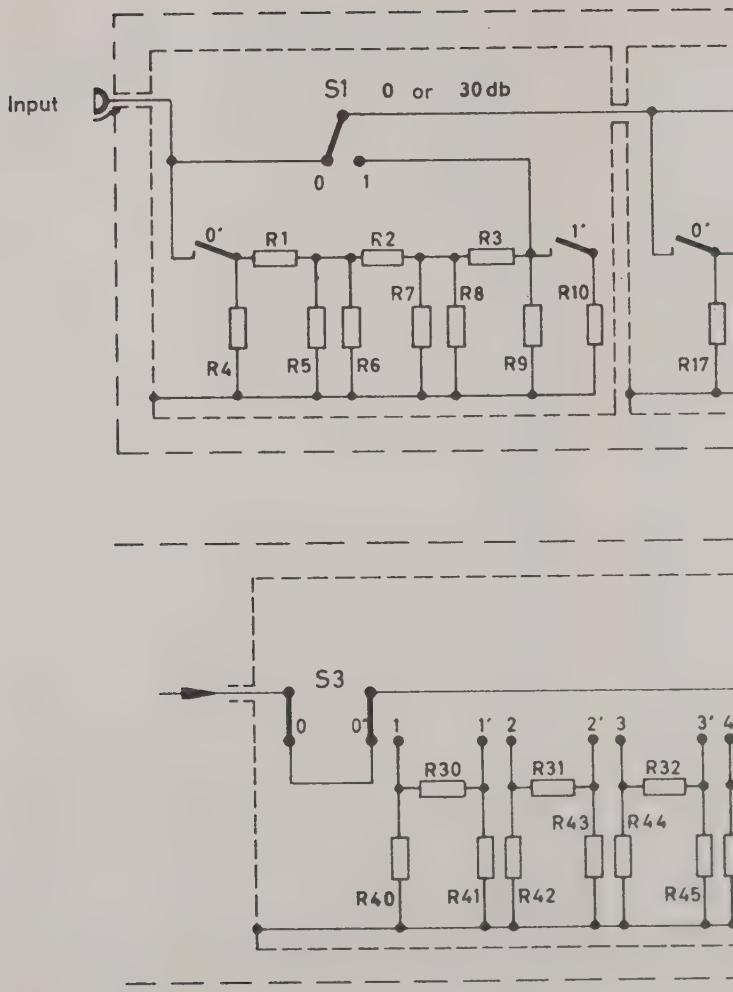
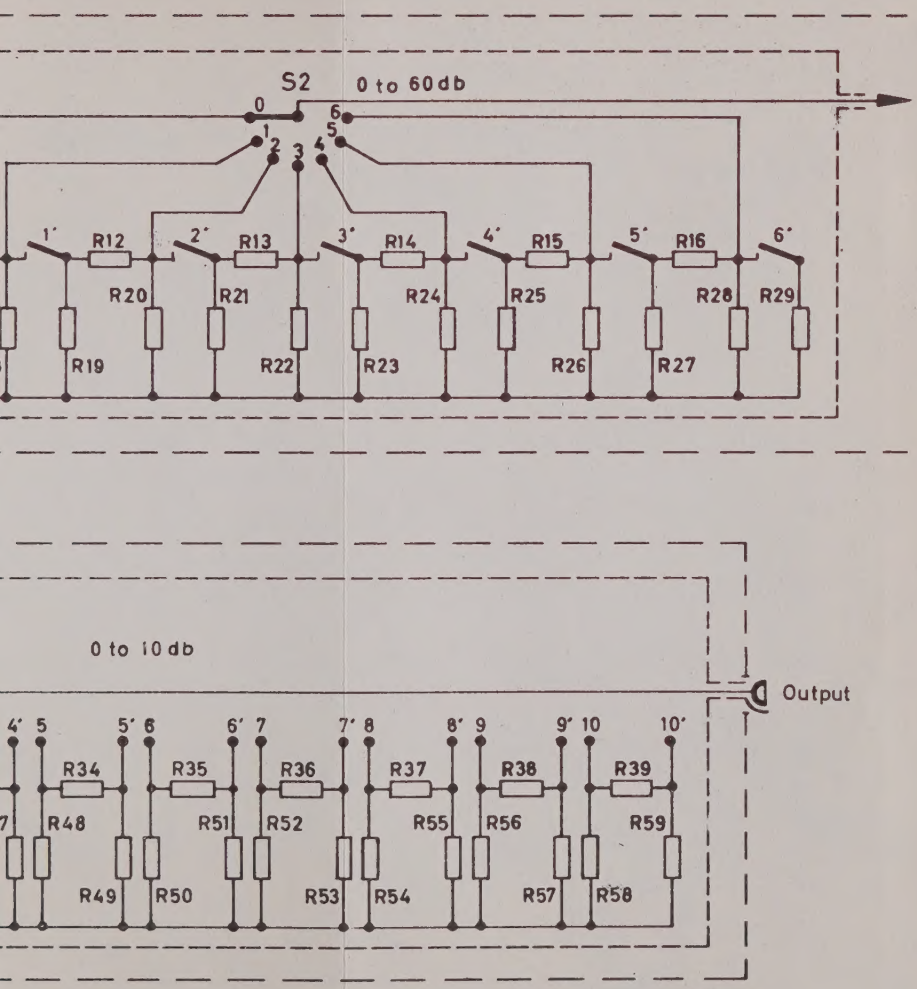


Fig. 10. Circuit diagram of the U



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